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CAVITATION TESTS ON A PROPOSED TEST VEHICLE WITH NOSE FINS

by

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Introduction

Cavitation tests were conducted in the High Speed Water Tunnel on a proposed projectile with control surfaces on the nose. These tests were carried out in cooperation with Dr. Dergarabedian of the Thompson Laboratory, Naval Ordnance Test Station. Qualitative tests of this type which included a photographic study of nose fin cavitation have proved valuable in indicating necessary modifications of the projectiles and in indicating the direction which further studies might take.

Models and Procedure

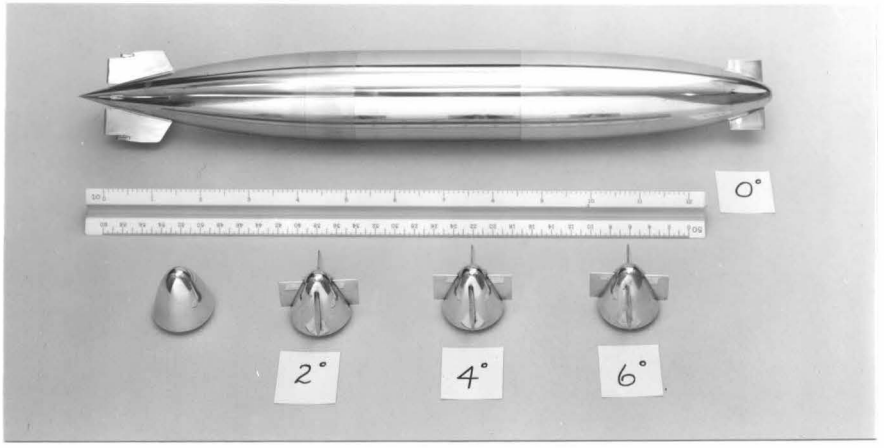


Fig. 1 - Model with Lyons Form A (L/D = 7.0) nose with fins and Lyons Form A (L/D = 5.0) afterbody

The model consisted of a 2-in. diameter Lyons Form A, (L/D = 7.0) nose with four fins, Fig. 1. The fins were short NACA 16-012 airfoils with a 0.763-in. chord and a total span of 1.526 in. All fins were finished with square tips. Four noses were used with the vertical fins set at 0, 2, 4 and 6 degrees and 0-degree horizontal fins. A Lyons Form A, (L/D = 5.0) afterbody with fins was used to complete the model. The model was set at 0, 3, and 6 degrees of yaw with the vertical fins turned in the direction of the yaw of the model.

The runs were made at 30 and 60 fps tunnel velocity and photographs were taken at various stages of cavitation from incipient to fully developed

cavities on the fins. Two cameras were used to obtain both side and top views of the model simultaneously using a short (2 to 3 microsecond) flash.

The cavitation number, $K = \frac{P_o - P_v}{\rho/2\ V^2}$ was obtained in the following manner: P_o is the static pressure measured at a point on the working section wall a short distance upstream from the model nose. P_v is the vapor pressure of water at the temperature of each run. The velocity V was determined in the usual manner by measuring the pressure drop across the tunnel nozzle.

Results

Cavitation first began at each yaw and fin angle configuration as thin single or double vortices shed from the square tips of the fins. As the working section pressure was reduced at constant velocity to decrease the cavitation number, the tip vortices grew larger and cavitation began on the face of the vertical fins. Further reduction in pressure on the yawed model resulted in large clear cavities coming from the entire vertical fins and covering much of the model nose.

Fig. 2 shows curves of cavitation number at which the tip vortices first became visible as a function of vertical fin angle and angle of yaw. Fig. 3 shows the cavitation number at which cavitation first began on the face of the fins. These curves are only approximations because of the small number of data points, the large number of variables, and the difficulty in pinpointing incipient cavitation on hydrofoils. There was no cavitation on the smooth nose model without fins at cavitation numbers as low as 0.14.

Figs. 4 through 8 show various stages of cavitation on the model nose at several fin angles and angles of yaw. As is evident in the photographs, a modification of the tips of the fins to produce weaker tip vortices should improve the cavitation characteristics of this type of nose. Work in this direction is being considered as well as possible force runs on a complete model with finned nose.

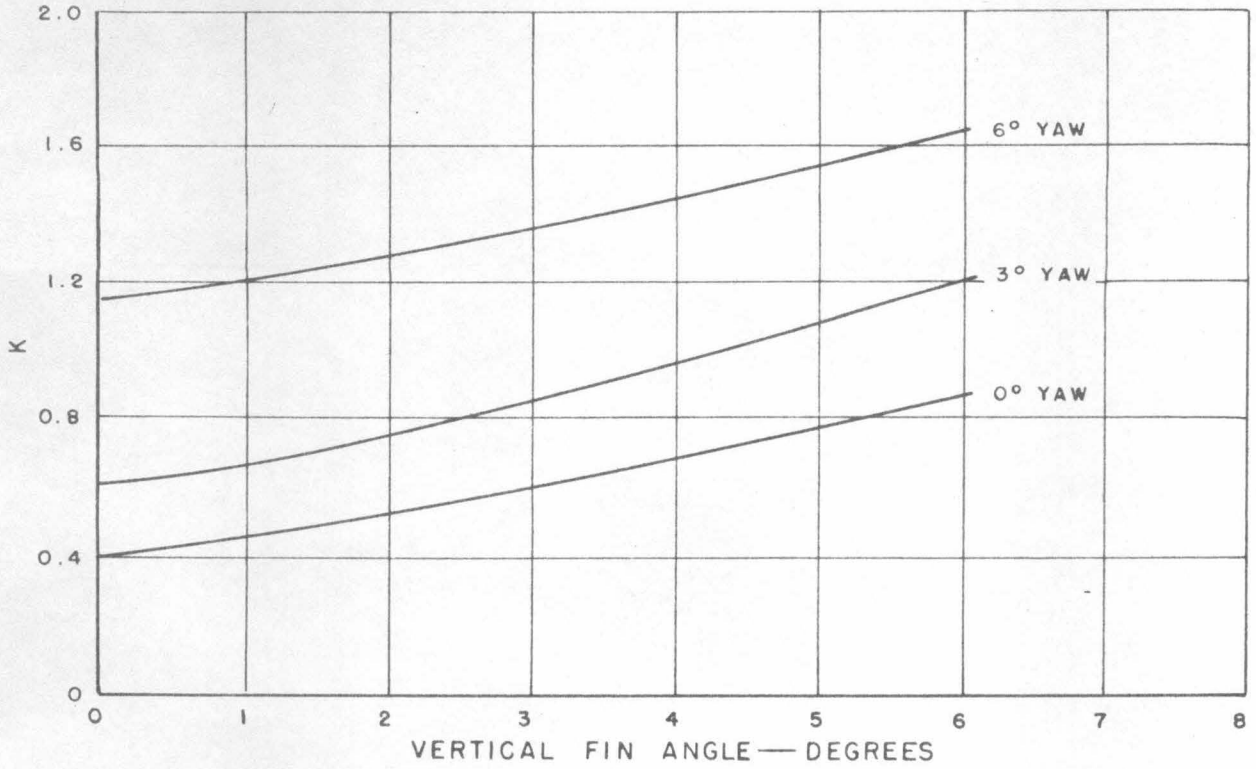


Fig. 2 - Vortex cavitation from tips of the vertical fins

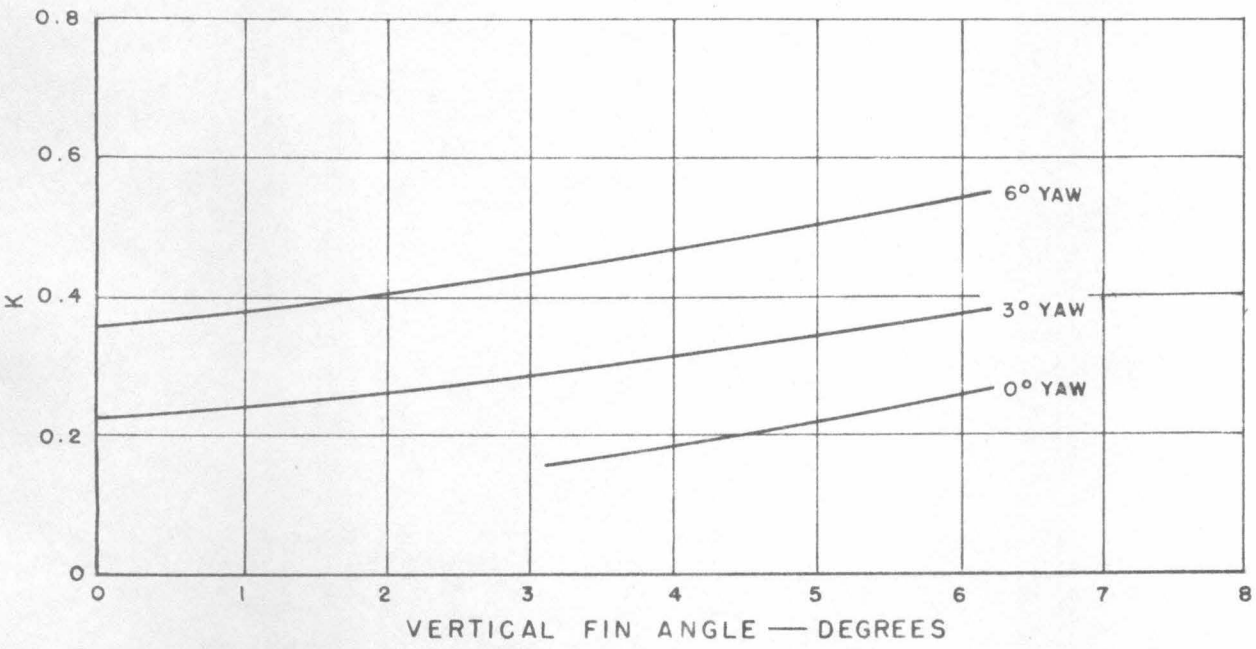
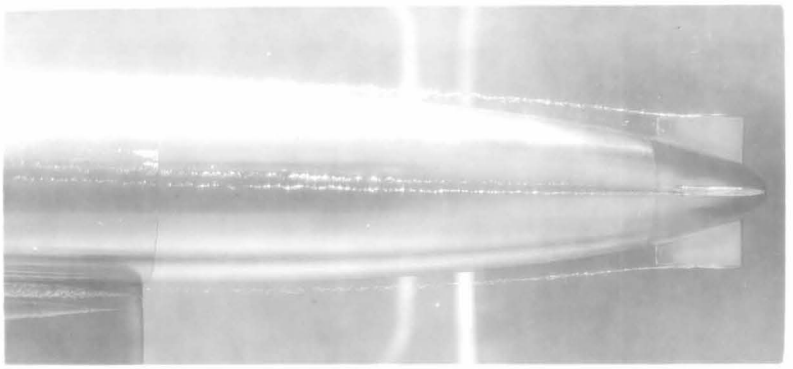


Fig. 3 - Incipient cavitation on the face of the vertical fins



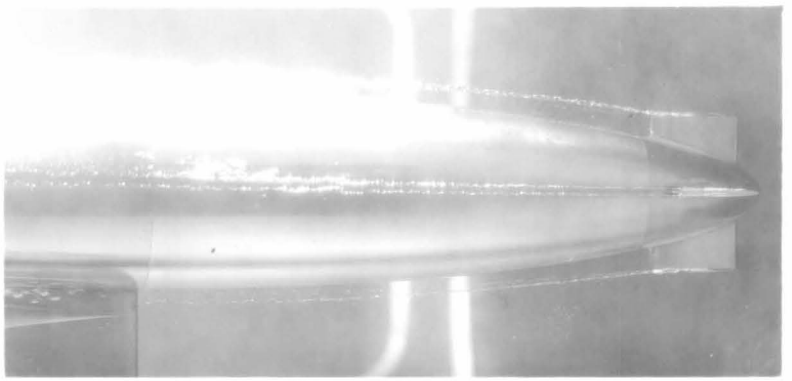
Side view

Yaw 0^{o}

Vertical fins 0^{o}

V = 56.7 fps

K = 0.13



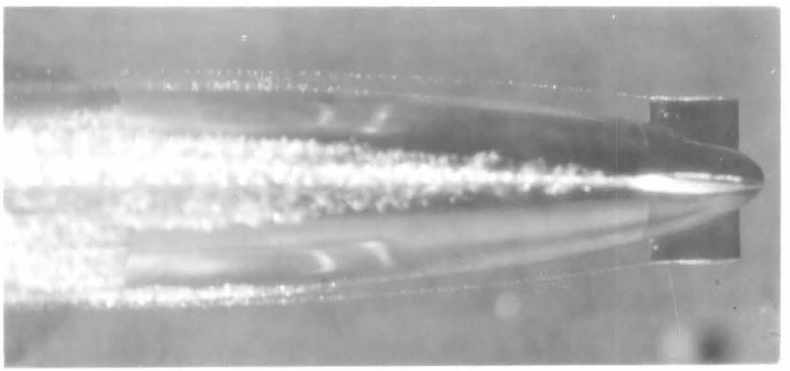
Side view

Yaw 0^{o}

Vertical fins 2^{o}

V = 58.6 fps

K = 0.13



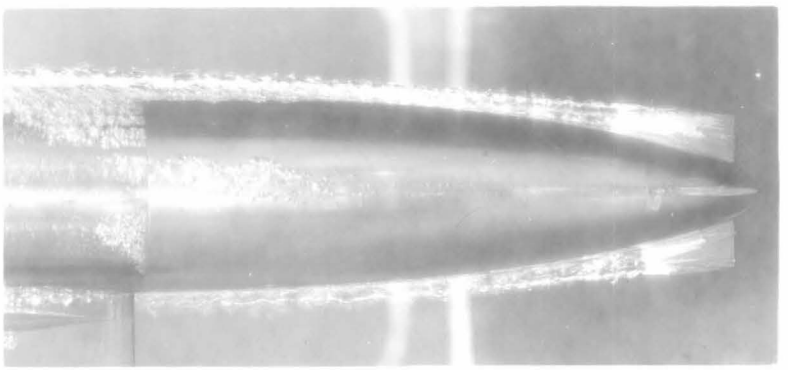
Top view

Yaw 0^{o}

Vertical fins 6^{o}

V = 59.5 fps

K = 0.12



Side view

Fig. 4 - Cavitation at zero degrees of yaw

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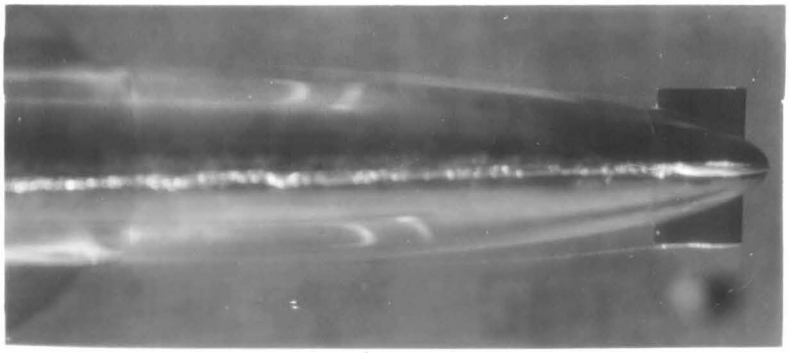
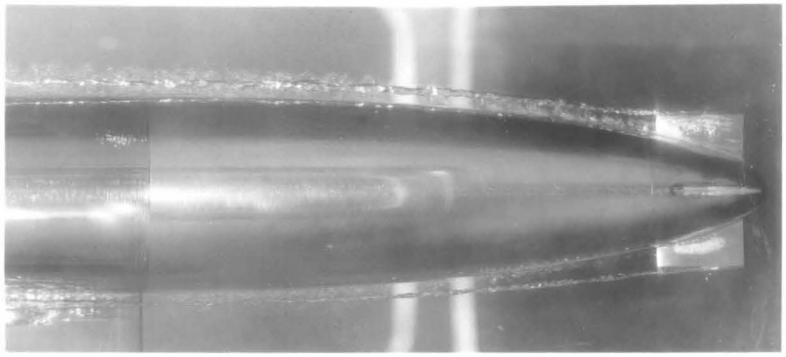
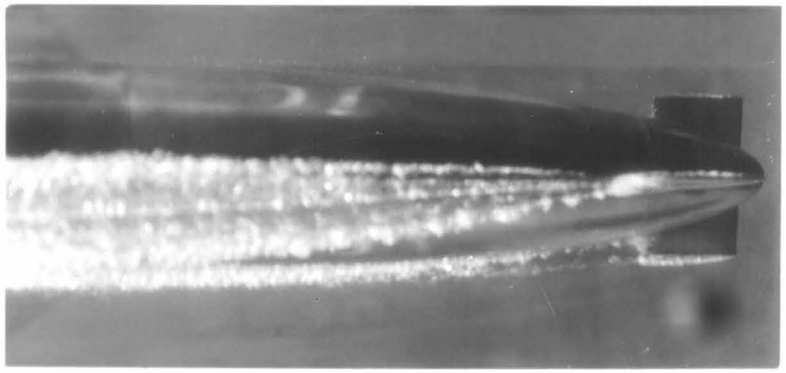


Top view

Yaw 3^{o}
Vertical fins 2^{o}
V = 59.8 fps
K = 0.22

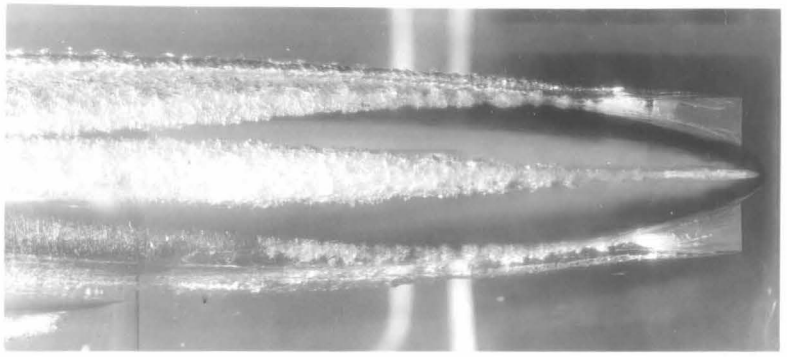


Side view



Top view

Yaw 3^{o}
Vertical fins 2^{o}
V = 58.2 fps
K = 0.13



Side view

Fig. 5 - Cavitation at 3 degrees of yaw

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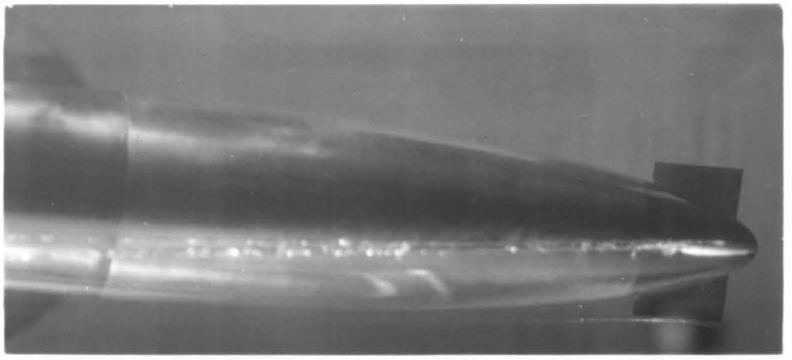
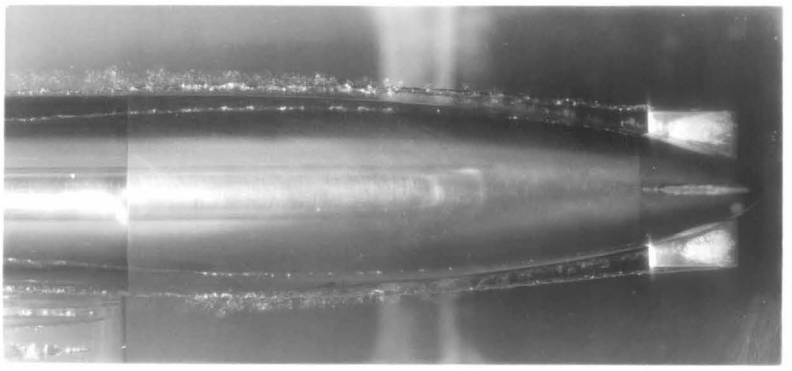
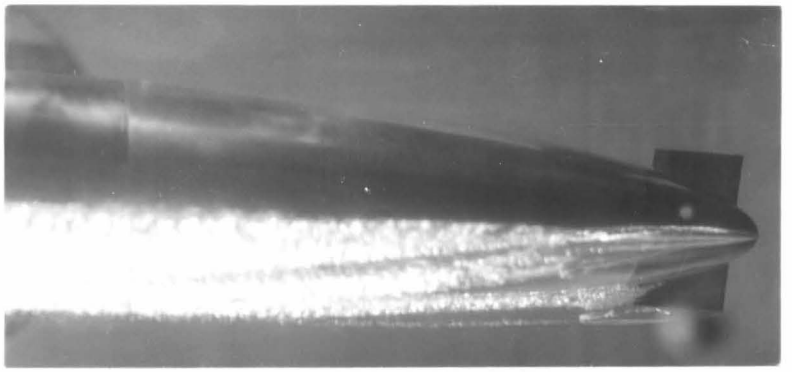


Top view

Yaw 6°
Vertical fins 0°
V = 59.8 fps
K = 0.34

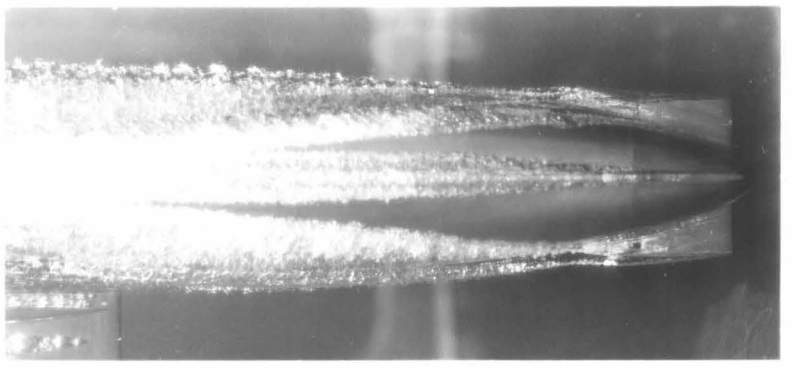


Side view



Top view

Yaw 6°
Vertical fins 0°
V = 58.7 fps
K = 0.13

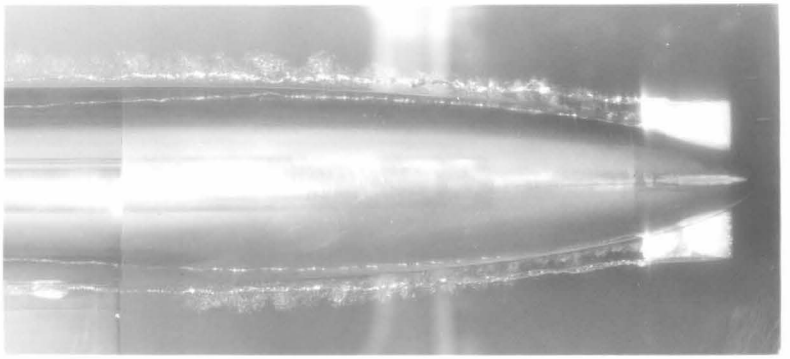


Side view

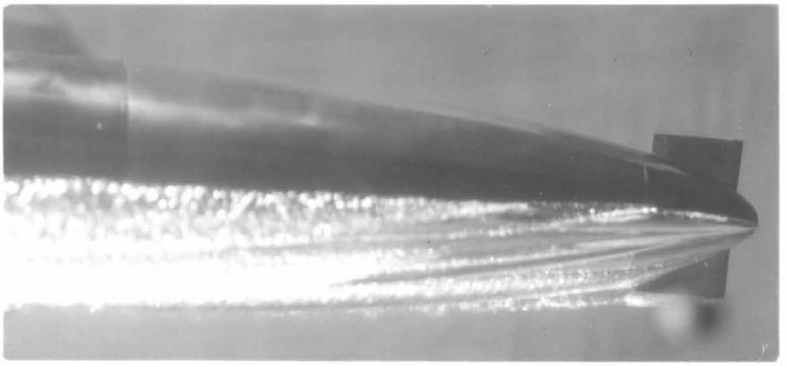
Fig. 6 - Cavitation at 6 degrees of yaw and 0-degree vertical fin angle

Top view

Yaw 6°
Vertical fins 4°
V = 60.2 fps
K = 0.48

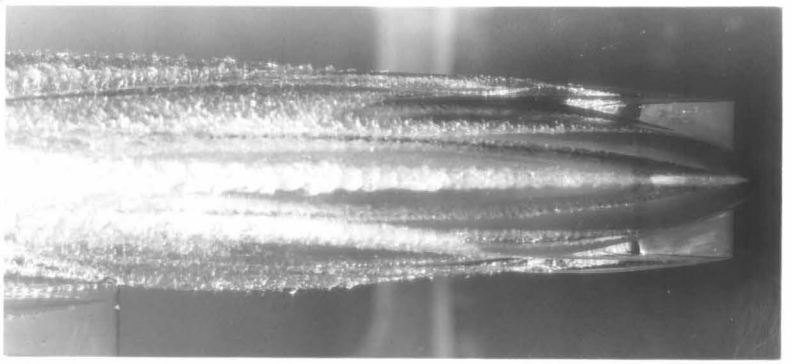


Side view



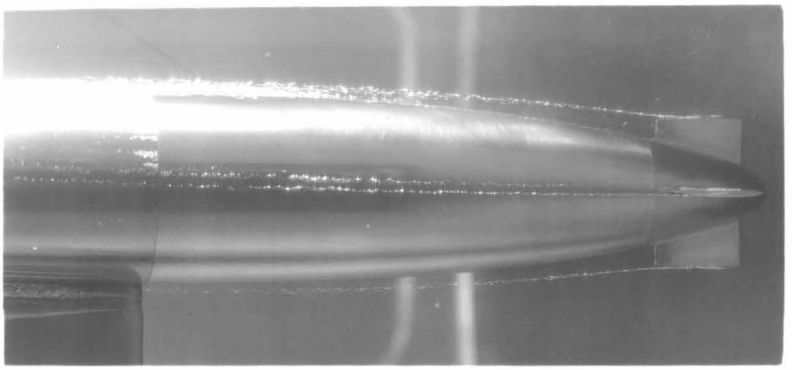
Top view

Yaw 6°
Vertical fins 4°
V = 59.6 fps
K = 0.14



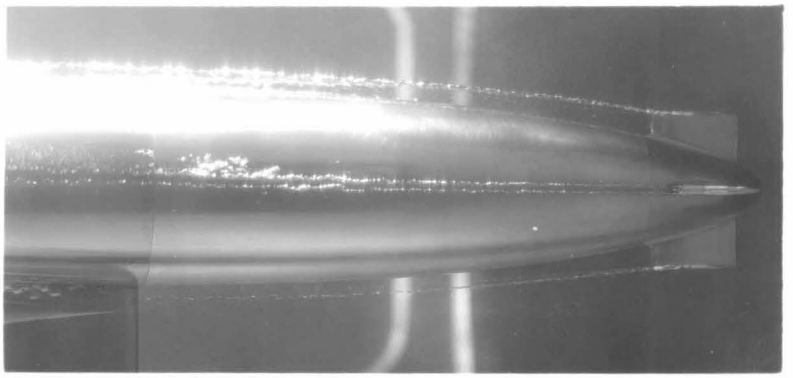
Side view

Fig. 7 - Cavitation at 6 degrees of yaw and 4-degree vertical fin angle



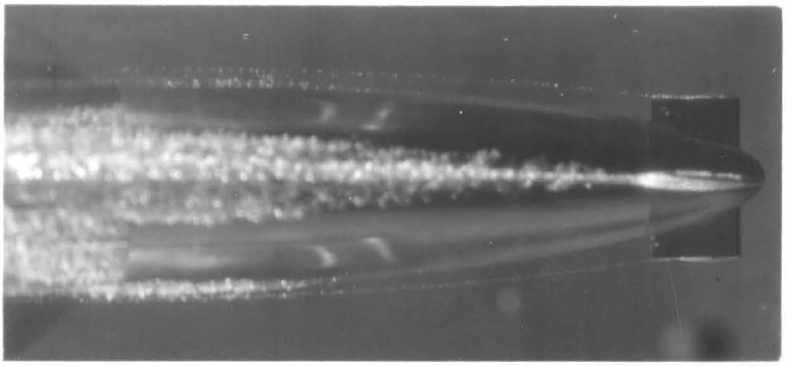
Side view

Yaw 0°
Vertical fins 0°
V = 56.7 fps
K = 0.13



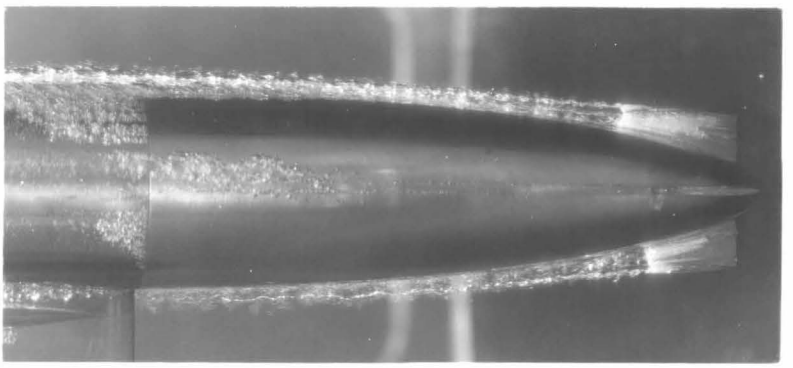
Side view

Yaw 0°
Vertical fins 2°
V = 58.6 fps
K = 0.13



Top view

Yaw 0°
Vertical fins 6°
V = 59.5 fps
K = 0.12



Side view

Fig. 4 - Cavitation at zero degrees of yaw